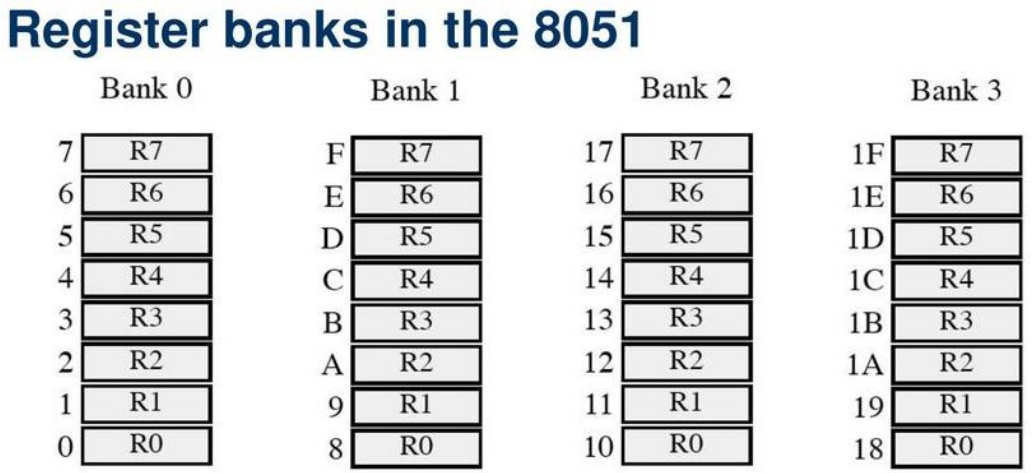
The Microcontroller Architecture:

- Introduction to 8051 Microcontroller,
- Architecture,
- Pin configuration,
- Memory organization,
- Input /Output Ports, Counter and Timers,
- Serial communication, Interrupts

- The 8051 microcontroller was invented in 1980's by Intel.
- Its foundation is based on Harvard architecture and this microcontroller was developed principally for bringing it to be used in **Embedded Systems**.
- At first it was created by using NMOS technology but the use of NMOS(N-channel metal-oxide semiconductor) consumed more power to work therefore Intel re-launch the microcontroller 8051 using CMOS(complementary metal-oxide semiconductor) technology and new edition came up with edition of letter 'C' in the title name, therefore the new modified version of microcontroller is called by name 80C51.
- The 8051 microcontroller programming is performed in **embedded C language** using Keil software.

Features of 8051 Microcontroller:

- It having four register banks
- 64K bytes on-chip programmable memory (ROM)
- 128 bytes on-chip data memory (RAM)
- Address bus is 16-bit unidirectional
- Data bus is 8-bit bidirectional
- 128 user defined flags
- 16 bit timers
- 32 general purpose registers each of 8-bit
- 8051 microcontroller offers a number of special features such as ADC, UARTs, Op-amp, etc.



B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0
CY	AC	F0	RS1	RS0	OV	-	P

CY — Bit 7 - Carry flag

AC — Bit 6 - Auxiliary carry flag for BCD operations

F0 — Bit 5 - User defined flag (Flag zero)

RS1, RS0 — Bit 4-3 - Select the working register banks as follows :

RS1	RS0	Bank Selection	
0	0	00H - 07H	Bank 0
0	1	08H - 0FH	Bank 1
1	0	10H - 17H	Bank 2
1	1	18H - 1FH	Bank 3

Fig. 12.3 Program status word

OV — Bit 2 - Overflow flag

– — Bit 1 - Reserved

P — Bit 0 - Parity flag (1 = Even parity)

Application of 8051 Microcontroller

Examples of embedded systems include the controllers in washing machines, the engine management systems in cars, and the flight control systems in aircraft.

- Home automation: The 8051 microcontroller can be used in home automation systems to control lighting, temperature, and security systems.
- Industrial control: The 8051 microcontroller is used in industrial control applications to control processes, machinery, and equipment. It can also be used to monitor and control temperature, pressure, and other environmental factors.
- Robotics: The 8051 microcontroller is used in robotics applications to control the movement of robots, sensors, and actuators.
- Automotive: The 8051 microcontroller is used in the automotive industry for engine control, anti-lock braking systems, airbag control, and other applications.
- Medical devices: The 8051 microcontroller is used in medical devices for patient monitoring, drug delivery systems, and other applications.
- Communication systems: The 8051 microcontroller is used in communication systems for data transmission, signal processing, and other applications.
- Consumer electronics: The 8051 microcontroller is used in consumer electronics such as remote controls, digital cameras, and smart home devices.

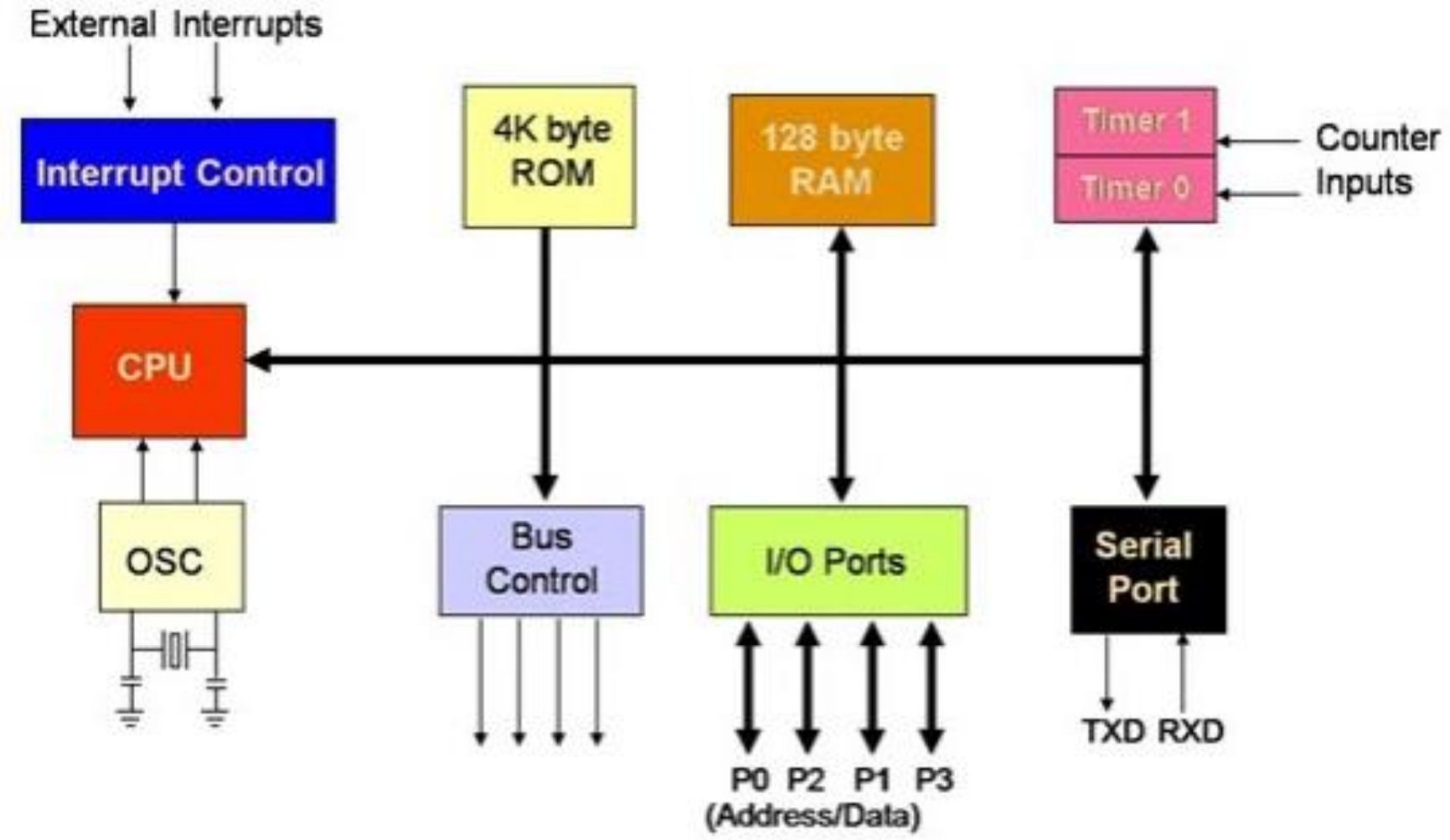
What is Microcontroller?

- A microcomputer made on a single semiconductor chip is called single-chip microcomputer. Since, single chip microcomputers are generally used in control applications, they are also called **microcontrollers**.
- Microcontroller contains all essential components of a microcomputer such as CPU, RAM, ROM/EPROM, I/O lines etc. Some single chip microcontrollers contain devices to perform specific functions such as DMA channels, A/D converter, serial port, pulse width modulation, etc.

- # 8051 Architecture

- In 1980, Intel introduced a powerful 8051 series of 8 -bit microcontrollers.
- They are the second generation of 8-bit microcontrollers.
- The 8051 microcontrollers are used for a variety of applications involving limited calculations and relatively some control strategies.
- They are used for industrial and commercial control applications, appliances control, instrumentation etc.
- The 8051 contains Boolean processor, full duplex serial port and power saving circuitry in addition to essential components such as 8-bit CPU, RAM, ROM/EPROM/OTPROM, timer/counter and parallel I/O lines.

8051 Microcontroller Architecture/Block Diagram



- Basic components present internally inside 8051 Microcontroller architecture are:
- **CPU (Central Processing Unit)**:
- CPU act as a mind of any processing machine.
- It synchronizes and manages all processes that are carried out in microcontroller.
- User has no power to control the functioning of CPU.
- It interprets the program stored in ROM and carries out from storage and then performs it projected duty.
- CPU manage the different types of registers available in 8051 microcontroller.

Interrupts:

- Interrupts is a sub-routine call that given by the microcontroller when some other program with high priority is request for acquiring the system buses the n interrupts occur in current running program.
- Interrupts provide a method to postpone or delay the current process, performs a sub-routine task and then restart the standard program again.
- **Types of interrupt in 8051 Microcontroller:**
- Let's see the five sources of interrupts in 8051 Microcontroller:
- Timer 0 overflow interrupt - TF0
- Timer 1 overflow interrupt - TF1
- External hardware interrupt - INT0
- External hardware interrupt - INT1
- Serial communication interrupt - RI/TI

IE (Interrupt Enable) Register

- This register is responsible for enabling and disabling the interrupt.
- EA register is set to one for enabling interrupts and set to 0 for disabling the interrupts.
- Its bit sequence and their meanings are shown in the following figure.

EA	-	-	ES	ET1	EX1	ET0	EX0

EA	IE.7	It disables all interrupts. When EA = 0 no interrupt will be acknowledged and EA = 1 enables the interrupt individually.
-	IE.6	Reserved for future use.
-	IE.5	Reserved for future use.
ES	IE.4	Enables/disables serial port interrupt.
ET1	IE.3	Enables/disables timer1 overflow interrupt.
EX1	IE.2	Enables/disables external interrupt1.
ET0	IE.1	Enables/disables timer0 overflow interrupt.
EX0	IE.0	Enables/disables external interrupt0.

IP (Interrupt Priority) Register

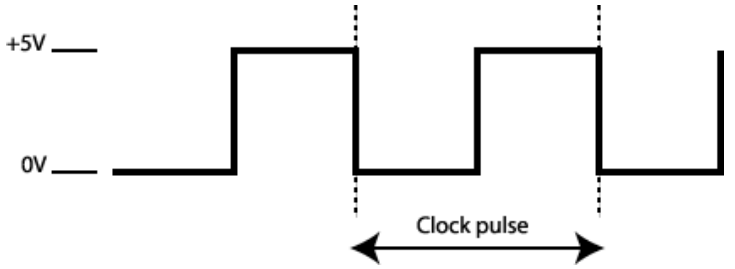
- We can change the priority levels of the interrupts by changing the corresponding bit in the Interrupt Priority (IP) register as shown in the following figure.
- A low priority interrupt can only be interrupted by the high priority interrupt, but not interrupted by another low priority interrupt.
- If two interrupts of different priority levels are received simultaneously, the request of higher priority level is served.
- If the requests of the same priority levels are received simultaneously, then the internal polling sequence determines which request is to be serviced.

-	-	PT2	PS	PT1	PX1	PT0	PX0
bit7	bit6	bit5	bit4	bit3	bit2	bit1	

-	IP.6	Reserved for future use.
-	IP.5	Reserved for future use.
PS	IP.4	It defines the serial port interrupt priority level.
PT1	IP.3	It defines the timer interrupt of 1 priority.
PX1	IP.2	It defines the external interrupt priority level.
PT0	IP.1	It defines the timer0 interrupt priority level.
PX0	IP.0	It defines the external interrupt of 0 priority level.

- TCON Register
- TCON register specifies the type of external interrupt to the microcontroller.

- **Memory**:
- For operation Micro-controller required a program.
- This program guides the microcontroller to perform the specific tasks.
- This program installed in microcontroller required some on chip memory for the storage of the program.
- Microcontroller also required memory for storage of data and operands for the short duration.
- In microcontroller 8051 there is code or program memory of 4 KB that is it has 4 KB ROM and it also comprise of data memory (RAM) of 128 bytes.
- **Oscillator**:
- As the microcontroller is digital circuit therefore it needs timer for their operation.
- To perform timer operation inside microcontroller it required externally connected or on-chip oscillator.
- Microcontroller is used inside an embedded system for managing the function of devices.
- Therefore, 8051 uses the two 16 bit counters and timers.
- For the operation of this timers and counters the oscillator is used inside microcontroller.



- **Bus** : Bus is a group of wires which uses as a communication canal or acts as means of data transfer.
- The different bus configuration includes 8, 16 or more cables. Therefore, a bus can bear 8 bits, 16 bits all together.
- **Types of buses in 8051 Microcontroller:**
- Let's see the two types of bus used in 8051 microcontroller:
- **Address Bus**: 8051 microcontrollers is consisting of 16 bit address bus. It is generally be used for transferring the data from Central Processing Unit to Memory.
- **Data bus**: 8051 microcontroller is consisting of 8 bits data bus. It is generally be used for transferring the data from one peripherals position to other peripherals.

Thank You